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AUTHOR Osborne, Roger; And Others
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ABSTRACT

The aim of the Learning in Science Project is to: (1) investigate science teaching/learning at the Form 1 to 4 level (ages 10 to 14); (2) identify some of the key difficulties in this subject area; and (3) find ways of overcoming such difficulties. The project is seen both as an evaluative and a research project in that it is concerned with obtaining information for decision-making (evaluation) and is also concerned with attempting to identify those factors which influence learning. To this end three phases of evaluation/research are envisioned: exploratory (observing teaching/learning and identifying difficulties perceived by teachers, students, and trained observers); in-depth (examining teaching/learning of science topics/themes; emphasizing development of concepts, skills, and attitudes relevant to the topics/themes); and action-research (exploring possible ways of overcoming identified difficulties and problems). The types of investigations to be carried out during each of these phases, intended audience, how project outcomes will affect teaching, ethical considerations, and time constraints are discussed. The nature of the science curriculum is also discussed under four headings: official curriculum; teachers' curriculum (teachers' intentions); actual curriculum (teachers' actions); and students' curriculum (variety of experiences/influences on students themselves). (JN)

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LEARNING IN SCIENCE PROJECT

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Learning in Science Project,
University of Waikato,
Private Bag,
Hamilton,
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AN INITIAL FRAMEWORK

A WORKING PAPER OF THE LEARNING IN SCIENCE PROJECT
Roger Osborne, Peter Freyberg and Ross Tasker
March 1979

Introduction

This paper sets down what we presently see as the major aim of the Learning in Science Project and suggests how this aim might be achieved. It attempts to take into account the various views of people who have been involved in the planning of the project up to this time.

The nature of the project

Out of the various possible aims which it has been suggested should be the focus of the project (Ralfe, 1978) the following statement seems to us to include the most important and realisable goals:

> The aim of the project is to make a study of the teaching and learning of science at the Form 1 - 4 level, to identify some of the key difficulties in this subject area, and to find ways of overcoming such difficulties.
>
> To this end three phases of evaluation and research are envisaged:
>
> (a) an exploratory phase, to observe the teaching and the learning of science in classrooms and to identify difficulties as perceived by teachers, pupils, and experienced classroom observers,
>
> (b) an in-depth phase, to focus on the teaching and learning of selected aspects of the science course e.g. topics or themes. It is expected that the selection will be based mainly on findings from the exploratory phase and that emphasis will be placed on student development of concepts, skills and attitudes relevant to selected aspects,
>
> (c) an action-research phase, based on the findings of the first two phases, to explore with teachers possible ways of overcoming the identified difficulties and problems in teaching and learning science.

The project is seen as both an evaluative and a research project in the sense that it is concerned with obtaining information for decision-making (evaluation) and yet is also concerned, particularly in the in-depth phase, with attempting to identify those factors which influence learning (research).

Exactly what is being investigated?

The project is primarily concerned with the Form 1 - 4 science curriculum. However, what is meant by the Form 1 - 4 science curriculum needs careful consideration. Let us consider this under four headings

(i) the official curriculum (official transmitted)
(ii) the teacher's curriculum (teachers' intentions)
(iii) the actual curriculum (teachers' actions)
(iv) the students' curriculum (students' received)

The official (national) curriculum is the Form 1 - 4 Science Syllabus. A revised draft syllabus was published in 1978. But the 1978 syllabus states that the 1967 syllabus "remains the approved syllabus and many teachers may elect to continue to use it as a basis for their programmes. However, all teachers are free to use the suggestions made in this draft if they consider them more helpful." Curriculum developers over the next two years aim to produce guidelines for each syllabus section from which teachers may plan classroom programmes. Six units for pupil use and teacher resources have already been written and supposedly updated for the new syllabus and are now being published. (Nevertheless, it should be pointed out that at least the first unit published has not been completely updated.) 40 - 50 small units (FORM 1 - 4) should be available as draft materials for trial schools in 1979. In summary, the official curriculum is the 1967 syllabus but modifications contained in the 1978 draft may be adopted if they are considered more helpful.

It seems likely that the teachers curriculum, i.e. what the teacher uses as the curriculum, will undergo considerable changes between 1979 and 1981 dependent upon the success of the support materials being produced by the Department of Education. A research project currently being undertaken in Scotland (Brown, 1975) is examining a similar situation in that country. The project is concerned, in part, with questions like

(i) who has taken up the new syllabus?
(ii) how are teachers implementing the new syllabus?

and is only then concerned with

(iii) what are students achieving?

The teachers' curriculum can be viewed as the teachers' intentions. With respect to this curriculum, recent changes in the official curriculum mean that an evaluative study undertaken by the project must take account of the possibly changing teachers' curriculum. Either it must address itself specifically to the problem as has been done in Scotland or it must ensure that the project is not undermined by the fluid situation.

Concern for the actual curriculum places a wider perspective on the Form 1 - 4 science curriculum than suggested above, if by actual curriculum one means everything which is deliberately organized by the teacher - the curriculum as identified by teachers' actions. In this sense, one is not only concerned with the content of the science courses but also with the materials used by the teacher and the organization within the classroom and the school.

The variety of experiences and influences on the pupils themselves will be called the student curriculum. Not only will this curriculum include aspects of the actual curriculum but it will also include the 'hidden' curriculum - that is the variety of experiences and influences on the pupils which are not planned, nor even necessarily acknowledged, but which may nevertheless influence pupils learning, attitudes and ideas as much as the intended experiences (Snyder, 1971).

In terms of the project's aim, aspects of the 'actual' and 'student' curricula are central to the work of the project. However the relationship between the aspects of these curricula and the associated aspects of the 'official' and 'teachers' curricula will need to be explored if teachers' actions are to be related to teachers' intentions. In the exploratory phase it would seem pertinent to consider a teaching and learning event in terms of all four curricula. To ensure that the 'in-depth' and 'action-research' phases are not undermined by changing curricula in the schools it is also necessary to consider the time dependence of the relevant aspects of each of the four curricula.

Who is the audience and how are the outcomes of the project going to effect teaching?

The project's audience will be a diverse one; teachers,

teacher trainers, curriculum developers, advisers, educational researchers and so on. Each of these audiences will be interested in different aspects of the project's findings. For example:

(i) information about teachers' difficulties caused by a lack of teacher training would be of particular interest to in-service and pre-service teacher trainers;

(ii) information about difficulties of pupils in seeing the relevance of a topic or pupil difficulties caused by a lack of appropriate prior experiences would be of interest to curriculum developers;

(iii) problems arising from mismatch between pupils' and teacher perceptions of classroom happenings could be referred to advisors and in-service agencies.

However if the project is going to affect teaching and learning in classrooms then the teachers themselves should be the prime audience. Brown and McIntyre (1978) have emphasized that suggested changes must include clear explanations as to what teachers should do in the classroom. It has been observed that a teacher pragmatically will label any proposals for change as 'practical' or not. If the change is seen as practical then it may be incorporated into the teaching; if not, then it is unlikely to be tried except under coercion. It is suggested that it is not enough to recommend principles or desirable outcomes to teachers. These must be accompanied by specification of procedures. The reality is that teachers in general cannot, or will not translate for themselves the lofty aims of a changed syllabus, or other innovations, into day-to-day activities.

If the above view is accepted then a reason for the emphasis in the project on classroom teaching rather than the official curriculum can be identified. Outcomes of the project related to suggested changes in the official curriculum may have a minimal effect on teaching and learning in the classroom even if the changes are adopted by the curriculum developers. On the other hand, information on how specific classroom problems may be overcome, or information on the possible consequences of particular classroom actions, are likely to have greater impact on classroom teaching provided these have been validated in an action-research phase.

Investigations in the exploratory phase

In the exploratory phase of the project the teaching and learning of science is to be observed and the difficulties in teaching and learning as perceived by teachers, pupils and experienced classroom observers identified. In this phase of the project selected aspects of the course, e.g. topics or themes, need to be identified for in-depth analysis in the second phase of the project.

Undoubtedly the exploratory phase of the project corresponds closely to the first stage of illuminative evaluation as suggested by Parlett and Hamilton (1977). There is an emphasis at this stage in observation at the classroom level and interviewing participating teachers and students. Parlett and Hamilton (1977) suggest that the researchers should be concerned to familiarize themselves thoroughly with the day-to-day reality of the setting without focus on particular aspects. Nevertheless we consider it is desirable to have certain broad observational frameworks on which received information can be ordered and categorized. As suggested earlier these frameworks may include

(i) viewing information in terms of official, teachers, actual and hidden curricula and being sensitive to the possible fluidity of these curricula with time;

(ii) attempting to identify concepts, topics or themes* which appear central to an on-going learning, which appear or are perceived by teachers or students as difficult to teach or learn, or alternatively are well liked and well understood by pupils and/or teachers;

(iii) attempting to identify other problems and difficulties, as well as the enjoyable and worthwhile moments, which teachers and pupils experience within the institutional and national educational system in which they operate;

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* e.g. the use of models or mathematics in science teaching

(iv) being conscious of the differences in learning milieu and the differences in the students themselves between the various types of schools which teach Form 1 - 4 Science in the Waikato area (one of the reasons the project was based at Waikato is the wide variety of schools in the area);

(v) being sensitive to differences and similarities between Form 1 - 2 Science and Form 3 - 4 Science. One interesting aspect of this project is the unique opportunity of the project to cover aspects of both primary and secondary education within the framework of one study.

While emphasis has been placed here on the difficulties or concerns perceived by teachers, pupils and classroom observers it may well be desirable to canvas views of other persons as well, about what they perceive as major concerns about the teaching and learning of Form 1 - 4 Science. These persons could include

(i) the teachers who teach students who have completed the course (e.g. Form 5 teachers);

(ii) the students who have taken the course (3rd formers about Form 1 and 2, 5th formers about Form 3 and 4);

(iii) the Headmaster and Head of Science;

(iv) the curriculum officers and science advisors; and

(v) interested groups in society e.g. parents, professional industrial.

Investigations in the in-depth phase

If Form 1 - 4 science is to be studied then there are a wide variety of aspects of teaching and learning that might be considered. Some of these are listed in Table I using the category system of Frazer (1977). Within the resources of this project, limitations must be made on what is to be studied. This can be done by selecting certain aspects of Table I, by limiting the content to be studied to certain topics or themes within the Form 1 - 4 Science course, and by limiting the groups of teachers and students to be studied.

One of the functions of the exploratory phase is to provide information so that a sensible approach can be made to specifying the scope of the in-depth phase. In particular, difficulties in teaching and learning will have been identified, topics or

Table I Aspects of teaching and learning Form 1 - 4 Science that could be investigated.

These can be listed using the category system adopted by Frazer (1977).

(i) Evaluation of the Form 1 to 4 Science Syllabus philosophy

e.g. the soundness of the stated aims, the soundness of the assumptions about society's needs, the soundness of assumptions about the mental capabilities of students.

(ii) Content analysis of Form 1 to 4 Science materials

e.g. relationship of stated aims to curriculum materials, logical structure of the materials in developing concepts and knowledge, authenticity of materials, readability and quality of presentation.

(iii) Learning environment in Form 1 to 4 Science classrooms

e.g. observation and classification of classroom events, students perception of the curriculum materials and their learning environment, teachers opinion surveys about problems and strengths in using the curriculum materials, case studies in classes where the Form 1 to 4 Science prescription is being implemented.

(iv) Student outcomes in classrooms using the Form 1 to 4 syllabus

e.g. long term and short term achievements of students with respect to the objectives of the prescribed syllabus.

(v) Dissemination of Form 1 to 4 syllabus and materials

e.g. the extent to which the syllabus aims and the associated teaching materials are being implemented in different schools, with different teachers, and in different classrooms.

themes central to the teaching and learning at this (and later levels) will have been specified, and particular aspects of Table I will have been isolated for further in-depth study. Apart from this dependence on findings from the exploratory stage it must not be forgotten that the development of students concepts, skills and attitudes form the central focus to teaching and hence to this project.

Ralfe (1978) has set out possible aspects of teaching and learning which might be investigated by the project using a case study approach. These include:

(a) What do teachers claim as their objectives; how do they see themselves proceeding toward these objectives; how is this related to the official curriculum objectives and to what teachers are actually doing in science classrooms? Freyberg (1979) distinguishes between teachers' purpose, intentions, plan of action, and actions in the classroom and it is desirable to distinguish between them as implied earlier in the discussion on the various curricula.

(b) What do pupils perceive as objectives of these same science lessons; how do they think they are proceeding toward these objectives; and what are the pupils actually doing?

(c) What are the backgrounds in science of the various teachers; what are their attitudes to the teaching; what is their depth of understanding of the science content in these science lessons?

(d) What are the backgrounds in science of the pupils; what is actually being attained in the science lessons in terms of concepts, skills and attitudes; what concepts and/or process skills appear too difficult for most pupils i.e. are introduced at an inappropriate stage in their cognitive development?

Measuring the effectiveness of teaching and learning in terms of student development is a major problem in education. In this regard it may be fruitful in terms of providing useful and fresh information to teachers and curriculum developers if the project were to use, where appropriate, measuring techniques not normally available to teachers because of time constraints

and so on e.g. individual interview methods, discussion with small groups, videotape supported analysis .

It is envisaged that in this in-depth phase of the study, the research work will go beyond identifying difficulties to isolate some of the factors which have a causal relationship to the difficulties and problems in effective learning.

Undoubtedly limiting the in-depth phase to certain topics, to certain research questions, and to certain groups of teachers or students, places some limitations on the generality of the findings. We expect to find some common elements in the limited number of aspects that we are able to pursue, which will produce conclusions of widerapplicability than statements related to just these aspects. The relationship between findings and audiences has been explored diagrammatically in Figure 1. Generality of the research findings is nevertheless a problem and it is one that has been of concern to researchers using the illuminative approach particularly where case studies have been used. Fensham, (1978) and Marsh et al, (1978, p.20) have suggested however that the important point is how much use the intended audience(s) can make of the information thrown up by the research findings. If generality is redefined in these terms, they suggest case studies and other illuminative approaches may well be of greater 'generality' than broad based psychometric studies.

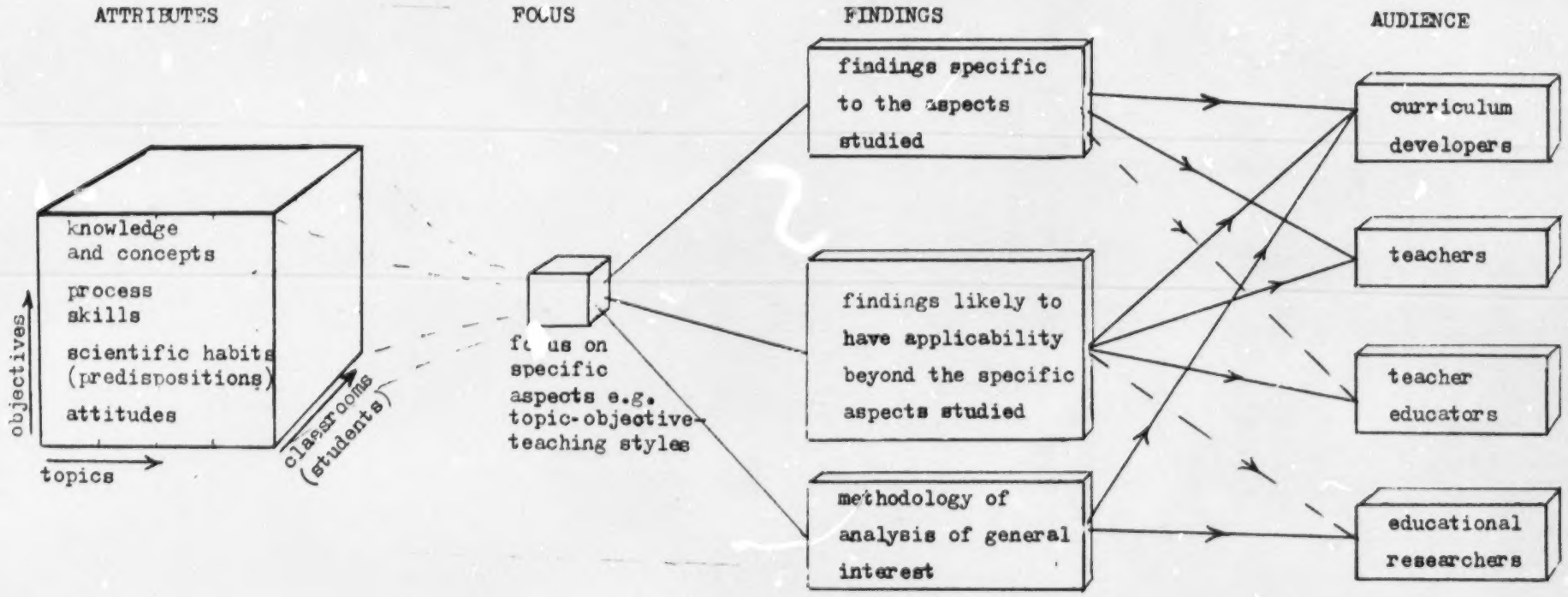
The project's advisory committee has suggested that with respect to providing information useful to teachers the findings of the project will need to set out the conditions under which certain outcomes are likely - teachers could then fit themselves into the situation (to the extent they considered appropriate) and use the information accordingly.

The action research phase

As the action-research phase is to be based on the findings of the first two stages the actual form this phase will take cannot be defined at this stage. However, what is clear is that in terms of this action-research phase of the project, the teachers are the crux to success. From this point of view the focus must be on issues that are seen by teachers to be important or issues which teachers can be convinced are important. Successful action-research necessitates awareness of the problems and the solutions

Figure 1 Focus on specific aspects of Form 1- 4 level Science

- not to the mutual exclusion of other aspects but rather an emphasis on specific topics, themes or objectives.



Criteria for choice of a specific aspect of Form 1-4 level Science, e.g. a topic

(i) topics which are perceived as difficult or a problem by teachers, pupils, or observers

(ii) topics which include central basic scientific concepts which will be built on later

(iii) topics which include a wide variety of process skills, scientific habits and attitudes

amongst the teachers who are actually doing the teaching. Harlen (1978), for example, has argued that a style of evaluation that involves teachers in deciding what information to gather, and how to gather it, and in discussing criteria for evaluating it, is more likely to benefit not only the individual schools but the system as a whole.

In this phase not only must ways be devised and tested for overcoming the difficulties uncovered in the earlier phases of the project but the effectiveness of the proposals must be critically evaluated.

Other considerations and constraints

Ethical considerations

Any research must be just and beneficial to all concerned i.e. the teachers, the pupils, the Department of Education, and others interested in the curriculum. Any evaluation makes the greatest demands on teachers, who quite naturally value their autonomy and privacy and are likely to find certain kinds of intervention or exposure threatening. It is important to realize, for instance, that teachers are likely to fear any evaluation which they consider might

(i) destroy in some way the personal relationship they have with students ;

(ii) possibly expose an incompetence of which they are unaware ; or

(iii) criticize them in unreasonable or subjective ways.

Teachers can also be concerned that their professional status will be undermined if they allow someone to comment critically on their work. These factors must be taken into account and may place constraints on the research work that can be undertaken in practice. The need to negotiate the clearance of information offered by participants and used as data in the research before distribution to anyone else, has been commented on by Simons, (1977).

Time considerations

The project is to run for two and one-half years and to ensure completion of the project in terms of a satisfactory end point, at least a tentative overall plan of action or time-table is required. Table II is an attempt to produce such a

Table II Timetable Plan for the Learning in Science Project

		EXPLORATORY PHASE	IN-DEPTH PHASE	ACTION-RESEARCH PHASE
1979	M	planning of the phase, goals and methods.*		
	A	familiarisation with the classroom	survey and design of possible measurement and observational instruments	
	M		trial of instruments	
	J	observer, teacher and pupils opinions canvassed and analysed		
	J		OVERALL METHODOLOGY CLARIFIED, TOPICS OR THEMES CHOSEN.*	
	A			
	S			
	O	further familiarisation but with respect to chosen classroom topics and teachers for the in-depth phase	training of observers, critical examination of topics or themes chosen, refining instruments to chosen topics, preliminary data collection	
	N			
	D			
1980	J		FINALISE DETAILS OF METHOD FOR THIS PHASE	survey and tentative design of this phase
	F			
	M		observation and measurement in the classroom with respect to specific themes or topics	
	A			
	M			
	J			development of this phase and trial of methods *
	J			
	A			
	S			
	O			
	N			
	D			FINALISE DETAILS FOR THIS PHASE
1981	J			
	F			work with teachers and in classrooms
	M			
	A			
	M			
	J			finalise write up
	J			
	A			REPORTS

* selection of schools, teachers and/or observers for the phase being considered

timetable. The details encompassed by the shaded boxes identify important points in the project planning.

Summary

The Learning in Science Project is particularly concerned with difficulties in teaching and learning Form 1 - 4 science. To investigate these difficulties a three phase project has been planned. The project is not seen simply as an evaluation exercise which is prescriptive and based on authority, nor will it involve large scale testing, nor evaluate either the syllabus or teaching. Rather it is seen as a research project concerned about finding ways of overcoming difficulties in the teaching and learning of science at the Form 1 - 4 level through small-scale in-depth studies. It is seen as something which can only be done collaboratively with teachers, and it is aimed at providing outcomes easily related to classroom decisions.

Teachers are often cynical about educational research and this cynicism is often justified in the sense that most research findings either confirm information that teachers knew all along or result in propositions so esoteric that they are seen to be of little relevance to classroom practice. Our task is to provide fresh and valuable information of relevance to informed decision making.

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